AFRICAN UNIVERSITY OF SCIENCE AND TECHNOLOGY, ABUJA

Pipeline Surveillance and Leakage Detection Systems with IoT and UAV

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Objectives

KEY DISCUSSIONS

Introduction - Background and Significance of Project
Brief Review of Similar Approaches
Research and Methodology
Evaluation and Discussions
Future work and Conclusions

Introduction

OIL PIPELINE NETWORK IN NIGERIA

Pipelines are a series of connected tubes utilised in the carriage and transportation of water, oil or gas over a long distance.

NOTABLE FACTS ABOUT THE PIPELINE NETWORK IN NIGERIA

- **MAJOR MODE OF TRANSPORT**

  Most of the hydrocarbon materials are transported using pipelines

- **A NETWORK OF ABOUT 16,000 KM**

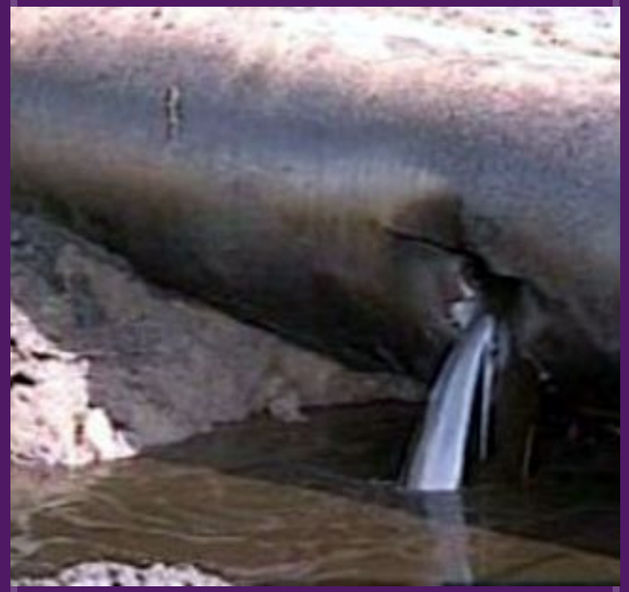
  Source: DPR, Eze, 2017

PROBLEMS

VANDALISM

18,667 incidences between 2002 - 2011
Okoli et al

LEAKAGES



After the event occured it cost about
800million USD to handle

EXPLOSION

Killed about 10 people in Rivers State in June 2019
Sahara Reporters

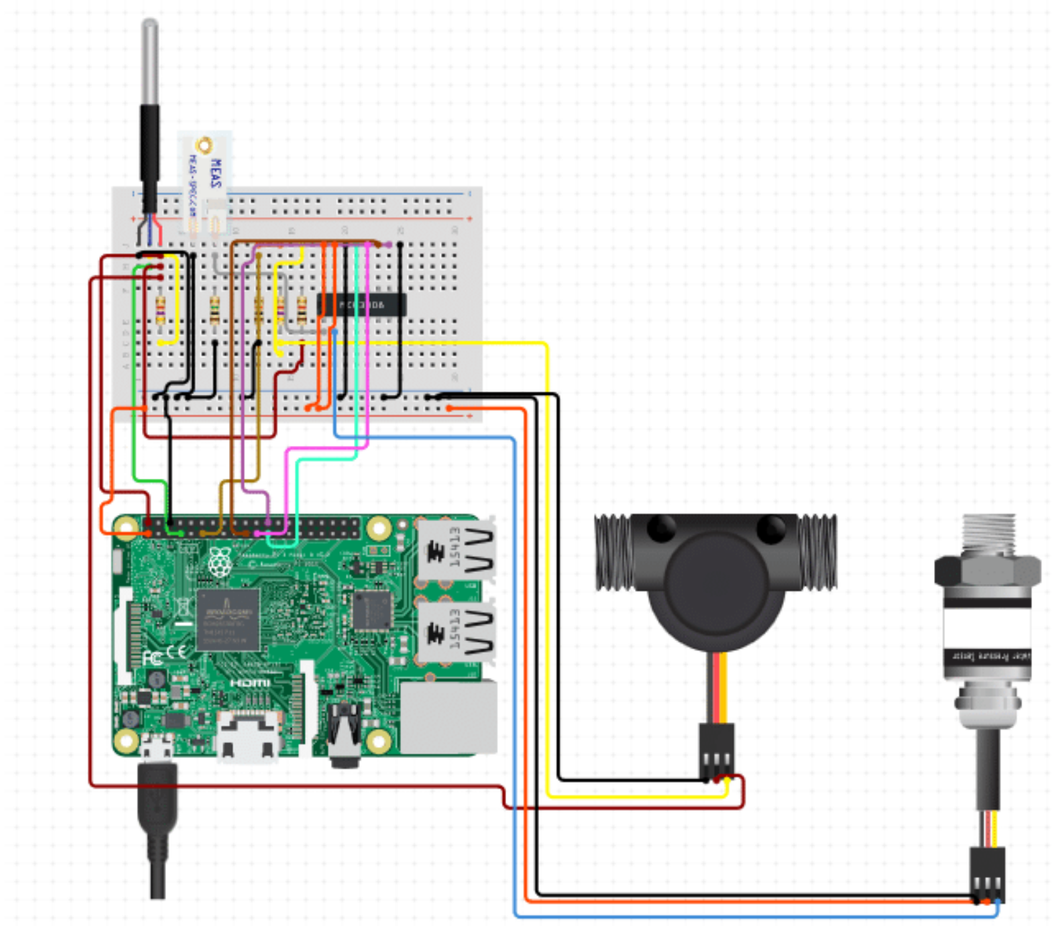
SIGNIFICANCE OF PROJECT

IMPROVED MONITORING

QUICK RESPONSE

PREDICTIVE ANALYSIS

IMPROVED SAFETY



Motives

TO EXPLORE THE UNIFICATION OF EXTERNAL AND INTERNAL SENSING TECHNIQUES FOR PIPELINE MONITORING

We believe this consolidation makes our proposed system unique and more effeicient when compared to other works

RELATED WORK - 1

LEAKAGE DETECTION AND ESTIMATION ALGORITHM FOR LOSS REDUCTION IN WATER PIPING NETWORKS

Adedeji, Hamam, Abe, & Abu-Mahfouz, 2017

Their work

They developed an algorithm that uses pressure sensors and flows meters to estimate and detect the background leakage flow.

Limitation:

Difficulties in detecting certain kinds of leakages due to treshold values

RELATED WORK - 2

AN ANTI-THEFT OIL PIPELINE VANDALISM DETECTION: EMBEDDED SYSTEM DEVELOPMENT

(Lukman, Adedokun, Nwishieyi, & Adegboye, 2018)

Their work

They developed an alert system with a GSM module and a piezoelectric sensor

Limitation:

Certain forms of vandalism may not be detected depending on the nature of the pipeline.

RELATED WORK - 3

PIPELINE DAMAGE AND LEAK DETECTION BASED ON SOUND SPECTRUM LPCC AND HMM

(Ai, Zhao, Ma, & Dong, 2006)

Their work

A leak detection mechanism was developed using acoustic signals; with a consolidation of Linear Prediction Cestrum Coefficient (LPCC) & Hidden Markov Model (HMM) .

Here, damaged acoustic signals were examined and analysed to detect damages or leaks on the pipelines

Limitation:

However, the effect of background noise can be a limitation as it tends to mask the actual sound leak.

RELATED WORK - 4

ABOVE GROUND PIPELINE MONITORING AND SURVEILLANCE DRONE REACTIVE TO ATTACKS

(Eluwande, A. D., & Ayo, O. O 2016)

Their work

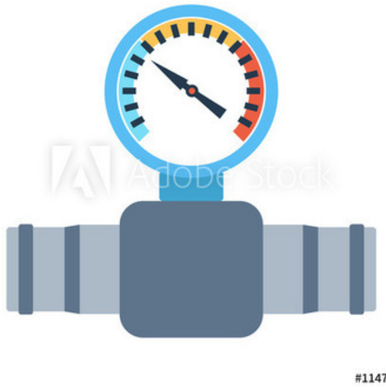
An unmanned aerial vehicle (UAV) machinery for real-time monitoring and surveillance of a pipeline network in a hazardous environment.

Limitation:

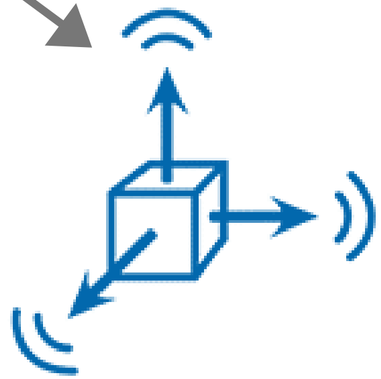
However, it was always necessary for a human to be there to assist in the monitoring and there was inadequate information about the structural and functional status of the pipeline.

Our Unique Methodology and Contribution

Interior Computational Sensing



Exterior Sensing



VIBRATION METER

Implementation

HARDWARE SUBSYSTEM

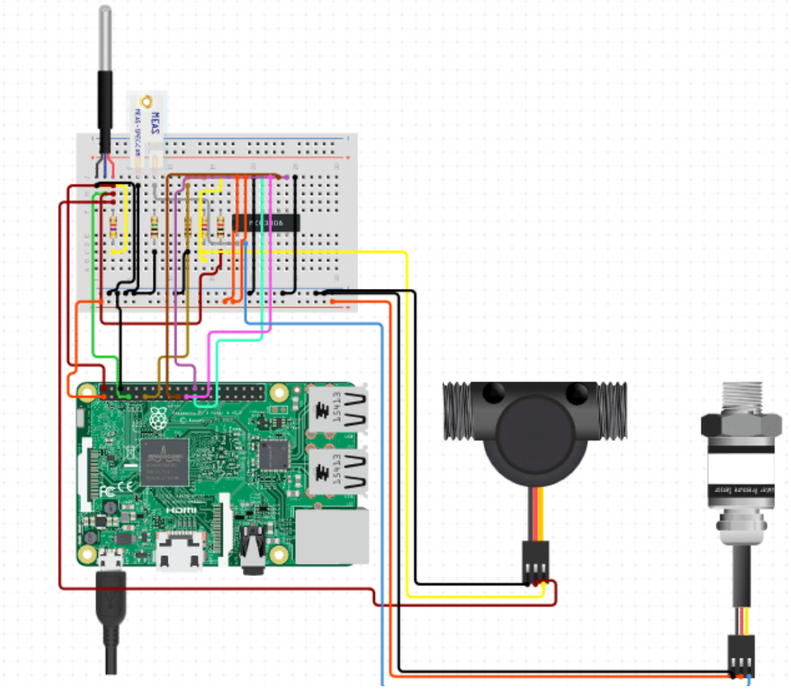
Drone Construction and IoT Deployment

SOFTWARE SUBSYSTEM

Web Interface, Image Analytics and Fuzzy Logic algorithm

DEPLOYMENT

Autonomous flight tests, leakage and vandalism experiments

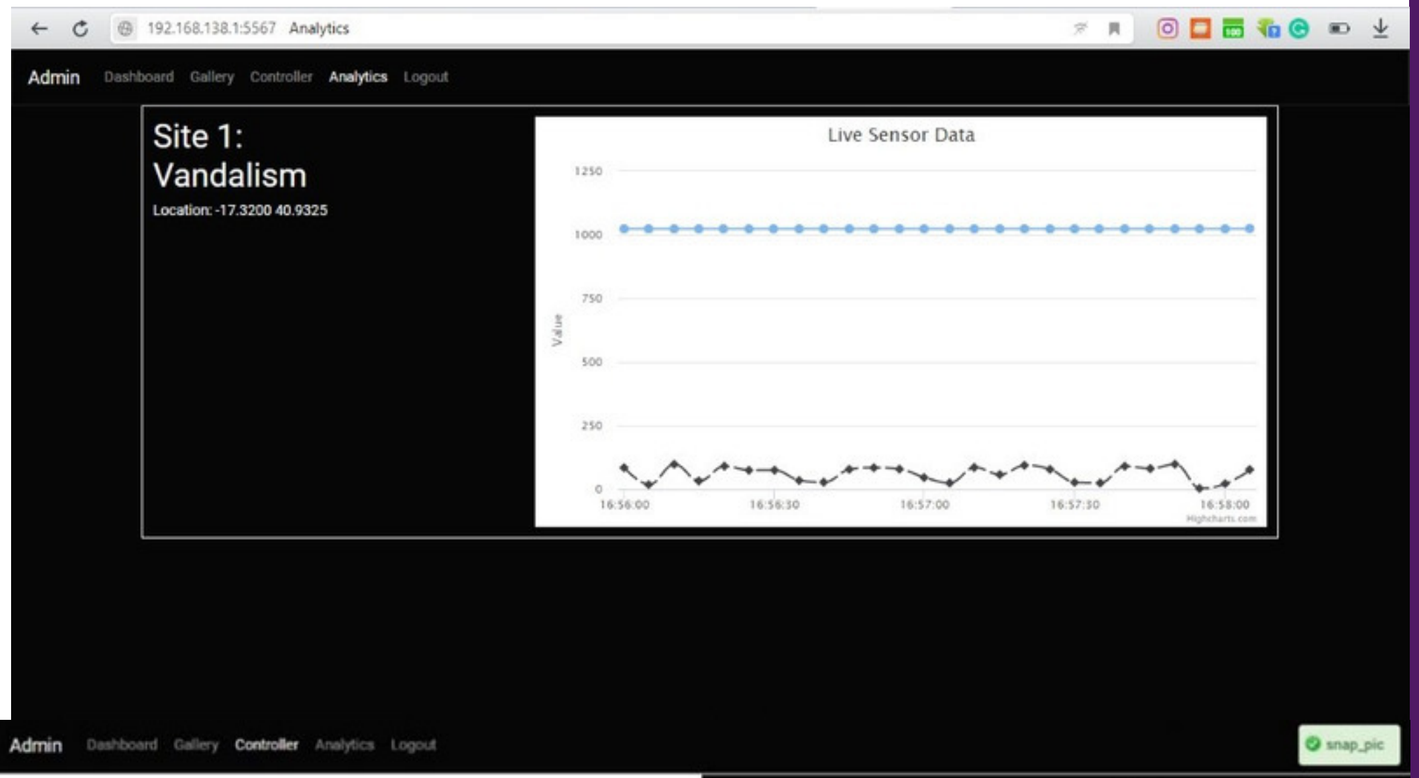


DRONE CONSTRUCTION COMPLETED

Drone fabrication with the minimum requirements to carry out required tasks - flight and image capture

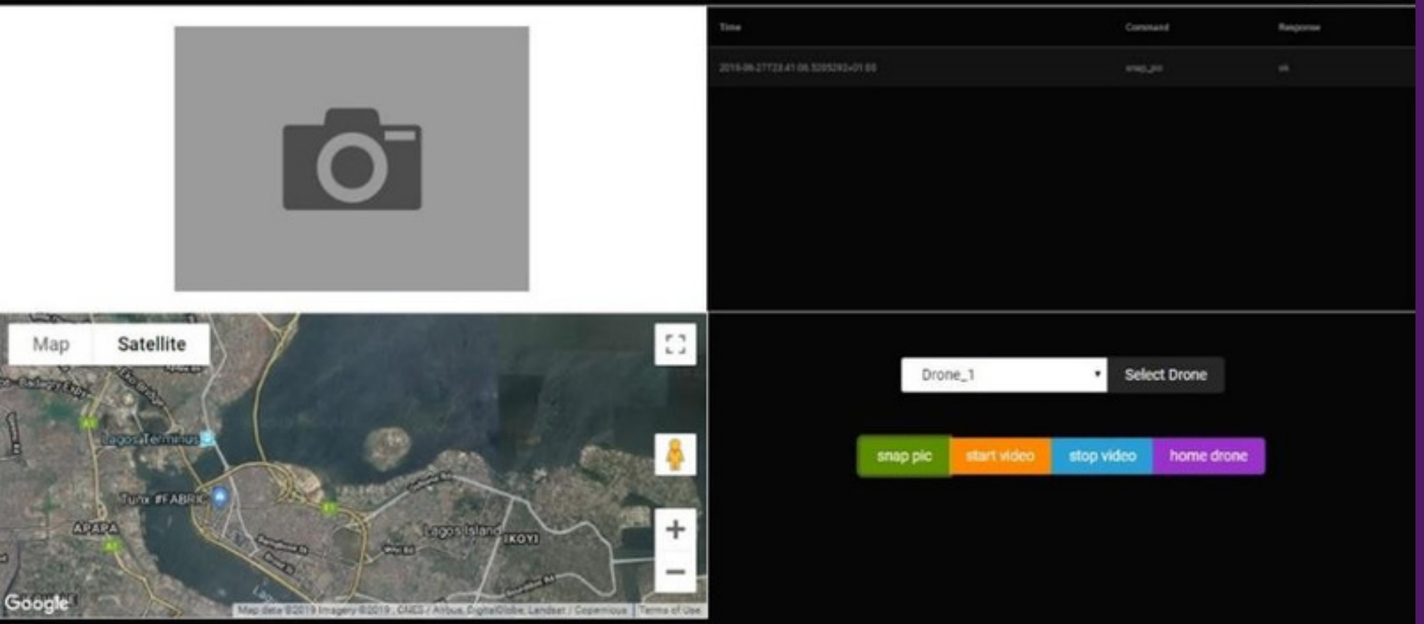
CONNECTION OF THE SENSORS

Connnection of sensors used for the vibration and pressure sensing



WEB INTERFACE TO MONITOR SENSORS

We developed a web interface to monitor sensor readings



WEB INTERFACE TO MONITOR UAV

We also developed an interface to monitor drone flight and vision

Vibration	Pressure			
	AND	High	Medium	Low
	High	Abnormal	Abnormal	Abnormal
	Medium	Normal	Abnormal	Abnormal
	Low	Normal	Normal	Abnormal

Table 1: Fuzzy rules used to calculate the degree of truth of the possible normal and abnormal events.

FUTURE WORK

OPTIMISED AUTONOMOUS FLIGHT

With Reinforcement Learning can we create better autonomous features for the drone?

BETTER ESTIMATE FOR LEAKAGE-DISTANCE ALGORITHM

We plan to utilise an artificial neural network to get better estimates of a leakage-distance

COMPUTER VISION

We also plan to carry out visual classification of leakages using a convolutional neural network

SUMMARY AND CONCLUSION

MAJOR CONTRIBUTION

We proposed a hybrid method to be used in the monitoring of pipelines with (1) External Sensing methods - vision and vibration
(2) Interior Computational Sensing Methods - Pressure

IMPACT

Our proposed impact will encourage automation, high-level monitoring, predictive analysis and improved safety

PATH FINDER

We also believe our proposed project will serve as an eye-opener on how artificial intelligence can be used to solve some peculiar use cases in the oil and gas industry in the Nigeria.

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